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INITIATIVES IN DIGITAL CONTENT MANAGEMENT: A CASE STUDY ON SARAS (INDIA'S FIRST CIVIL AIRCRAFT PROGRAMME)

R Guruprasad
Khaiser Nikam

The National Aerospace Laboratories (NAL), Bangalore, India's premier civil R&D establishment in aeronautics and allied disciplines, has embarked on a major civil aircraft development programme to build a multi-role light transport aircraft named SARAS. Initiatives were taken by the Information Management Division of NAL in setting up a state-of-the-art multimedia laboratory combined with the judicious selection of appropriate digital camera infrastructure. This paved the way for a systematic approach to digitally capture, archive and retrieve "SARAS digital information".

As an ambitious initiative carried out in digital content management, the SARAS aircraft programme has so far generated nearly 6621 minutes of digitally recorded video during the period 2002 – 2006 archived on to 172 digital magnetic tapes. And most importantly, close to 0.255 terabytes of SARAS digital video have been archived onto DVDs spread over 55 DVDs. Digital video will remain an expensive medium, in terms of broadcast/download time and navigation/seeking time. It is extremely clear that 'metadata' provide the window of access into a digital archive and the quality of digital archive is sine-qua-non with its metadata. NAL's initiatives in following a disciplined and systematic 'metadata' approach in archiving and retrieving digital video content of the country's most ambitious civil aircraft programme are highlighted in this paper.

INTRODUCTION

Nearly two exabytes (an exabyte is a billion gigabytes, or 10^{18} bytes) of unique information is produced throughout the world every year. This is roughly 250 megabytes of information for every man, woman and child on this planet Earth. According to a study by Lyman and Varian, printed documents of all kinds comprise only 0.003% of the total information¹. It is observed that magnetic storage is becoming the universal medium for information storage. As per circa 1999 statistics, the worldwide production of original content, stored digitally shows a clear "dominance of digital content". Digital information production is not only the largest; it is also the most rapidly growing. According to Kyong-Ho Lee, et al.², information preservation is one of the most important issues in human history, culture, economics as well as for the development of our civilization. A revolutionary change has occurred in the information storage field with the invention of electronic storage media. Digital technologies enable information to be created, manipulated, disseminated, located, stored and accessed with increasing ease. Ensuring long-term access to the digitally stored information poses a significant technological challenge. Preservation of digital information is complex because of the dependency of digital information on its technical environment. According to Alison Bullock³, to increase the probability that digital objects will be preserved, organizations need

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to lay the appropriate groundwork. The best practice would be to adopt a three-part approach: I use current standards to create digital objects I monitor standards as they change I migrate to new standards as they are established.

Three striking factors emerge from the study of Lyman and Varian: (a) "Paucity of print", (b) "democratization of data" and (c) "significant dominance of digital content". Not only is digital information production the largest in total; it is also the most rapidly growing. While unique content on print and film is hardly growing at all, optical and digital magnetic shipments are doubling each year. Even today, most textual information is "born digital", and within a few years this will be true for images as well. Moreover, the digital information is inexpensive to copy and distribute, is searchable, and is malleable.

It is clear that moving image archivists will continue to play a crucial role in preserving our cultural heritage and ensuring that today's works will last well beyond the life of the team that produced them. Thus, the lifetime of the metadata that index the content can far exceed that of the original content.

DIGITAL INFORMATION PRESERVATION: SOME ISSUES AND CURRENT STATUS

While the earliest information was recorded in carvings on stone, ceramic, bamboo, or wood, the development of civilization paved the way for new storage media and techniques for recording information, such as writing on silk, palm leaves or printing on paper. Eventually it was possible to put photographic images on film and music on records. With the invention of electronic storage media, a revolutionary change has occurred in the information storage field. According to the authors, with the advent of high-performance computing and high-speed networks, the use of digital technologies is increasing rapidly. Ensuring long-term access to the digitally stored information poses a significant challenge, and is increasingly recognized as an important part of digital data management. Most importantly, as newer digital technologies rapidly appear and older ones are discontinued, information that relies on obsolete technologies soon becomes inaccessible. Therefore, digital resources present more difficult problems than conventional analog media such as paper-based books².

"Digital Preservation" or "digital archiving" according to Alison Bullock³, means taking steps to ensure the longevity of electronic documents. It applies to documents

that are either "born digital" and stored on-line (or on CD-ROM, diskettes or other physical carriers) or to the products of analog-to-digital conversion, if long-term access is intended. Maintaining the accessibility of digital media, however, is much more complex than with non-digital media such as paper. For example, when a book is preserved in its original format, all aspects of the book are preserved – its physical appearance, its format, its layout, and its content. It is practically impossible to extract individual elements (e.g., content without layout) because they are inextricably linked. Even reformatting to paper or microfilm does not completely divorce content from layout as page sequences and physical appearance, for instance, can still be captured. Digital objects, in contrast, are easily decomposed into individual elements and significantly more effort must be made to preserve them as a "whole". For example, one can retain the content of an electronic document, while losing the layout. Further, one can keep its physical presence (i.e., a file), but fail to preserve its readability.

Several strategies have been indicated by Bullock³ to address the primary preservation problem of technological obsolescence. They include migration, emulation, preservation on permanent paper or microfilm and preservation of technology.

A recurrent theme in digital preservation guidelines³ is documentation and description of electronic resources. The need for such deliberate description stems in part from the fact that digital objects do not carry the visible evidence of creation and use (imprints, bindings, bookplates, marginalia, or Scotch tape) of non-electronic formats. Such clues guide preservation decisions. A description of a digital object is "data about data", or "metadata". Such descriptive data should include the contextual information crucial to the long-term management of electronic information. Metadata elements useful in preservation may include: I identifiers I hardware, OS and software required to access a document I physical details of tangible format publications such as CD-ROM, floppy disks I encoding standard and version I data to assist determining authenticity I rights management information I versions and dates. Other important strategies would include, giving unique identifiers to digital objects (assigning it with a unique and persistent identifier). This would establish the authenticity of the object by confirming to a user that the resource he/she is accessing is the one cited. Linking metadata with content is another important strategy. One way of linking metadata and the digital object is to package them together. Another way in



Figure 1: SARAS is India's Multi-Role Light Transport Aircraft

which libraries and archives are assuming control of digital preservation is by forging partnerships.

NATIONAL AEROSPACE LABORATORIES AND SARAS

The National Aerospace Laboratories (NAL), Bangalore, which is a constituent of the Council of Scientific and Industrial Research (CSIR), is India's pre-eminent civil R&D establishment in aeronautics and allied disciplines. NAL's primary objective, as articulated in its new Vision Statement, is the "development of aerospace technologies with a strong science content and with a view to their practical application to the design and construction of flight vehicles". NAL's core competence spans practically the whole aerospace spectrum.

NAL has embarked on a major civil aircraft development programme to build a multi-role light transport aircraft named SARAS. It is capable of being used in various roles such as feeder line aircraft, air taxi, air ambulance, executive aircraft, troop transport, aerial survey and reconnaissance, light cargo transport etc. SARAS is capable of flying upto a maximum speed of 550 km/ hour

at a cruise altitude of 7.5 km⁴. Figure 1 shows SARAS during its initial taxiing and flight trials.

A STATE-OF-THE-ART MULTIMEDIA LAB – NAL INITIATIVES

As the SARAS activity was gathering momentum, it was indeed absolutely essential for NAL to have a sound and robust strategy to digitally archive still photographs and digital videos of this programme. The Information Management Division of NAL was entrusted with the task of setting up a modern multimedia lab and devising suitable mechanisms to archive the invaluable video footages and photographs that this programme would generate. This was also the beginning of a new adventure in NAL, i.e., entering the digital paradigm^{5,6}.

Table 1 summarizes the hardware and software platform used in setting up this state-of-the-art multimedia lab at NAL. Digital video editing and 3D animations take a heavy toll on the resources of a computer system. Hence, it was decided to move from the Intel Pentium platform to the AMD Athlon platform, which was slowly emerging in the Indian market somewhere around late 2002. The modern

[A] The Hardware: (a) ASUS TeK Computer INC. Motherboard, (b) AMD Athlon MP Palomino (1.6 GHz) dual processor, (c) 1 GB Kingston RAM, (d) 128 MB NVIDIA GeForce4 Ti4600 video display card, (e) Multi-Bay Server Cabinet, (f) 400W ATX Power Supply Dual Redundant, (g) Matrox NLE RT 2500 DVE Card, Matrox DV/MPEG Codec Drivers, (h) 21" Samtron Flat CRT Monitors, (i) Ultra SCSI hard drives (striped) of 206 GB based on the RAID architecture: Video Station, (j) IDE hard drives with 4MB cache (1 x 120 Gb and 1 x 40 GB: Video Station), (1 x 80 GB and 1 x 120 GB: Graphics Work Station), (k) LG CD Writers, Samsung DVD-ROM drives and SONY DVD Writer, (l) 14" SONY Video Monitor, (m) SONY DSR-45P digital video cassette recorder, (n) A dedicated SONY 2400 W Audio and VCD. **[B] Equipping Ourselves with the Right Software:** (a) Adobe Digital Production Suite (consisting of Adobe Premiere, Adobe Photoshop, Adobe Illustrator and Adobe After Effects), (b) 3D Studio Max, (c) 3rd Party MPEG converters. **[C] Colour Proofs for CD-Printing and CD-Printing Device:** (a) Tektronix Phaser 750 P (a true 1200 x 1200 colour laser printer), (b) EPSON CD-Printer.

Table 1: Hardware and Software Specifications for the Multimedia Studio at NAL.

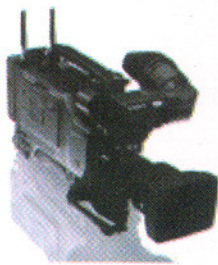


Figure 2: The Multimedia Lab at the Information Management Division, NAL

multimedia lab set up at the Information Management Division, NAL is shown in Figure 2.

SIGNIFICANCE OF DIGITAL VIDEOGRAPHY IN AN AIRCRAFT DEVELOPMENT PROGRAMME

Digital videography is an invaluable tool for all post-flight analysis for investigations and arriving at significant conclusions in an aircraft development programme. Especially, real-time video is extremely crucial to a flight test director. During critical phases like take off and landing of an aircraft, availability of real-time video gives a better appreciation of the aircraft attitude, pitch angle, flare etc. to the flight test director. It is an important visual aid for

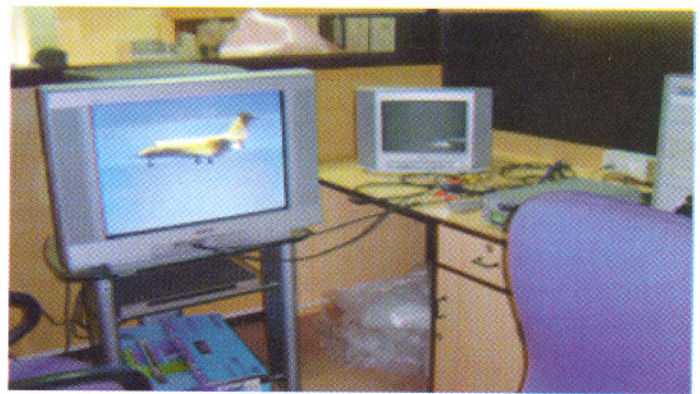


The Digital VideoGraphy Infrastructure:

- Sony 390 PK1 digital video camera with a 19X zoom equipped with a 1/2 inch Power Advanced Hold Accumulation Diode (HAD) Charge Couple Device and with a high density of 430,000 pixels (PAL)
- 0.25-

0.5lx of minimum illumination to shoot. ● SONY DSR-45P digital deck supports recording facility up to 4.5 hours of digital video on a 184 minute DVCAM tape. This has a Fire Wire interface to enable digital recordings without generation loss ● SHURE lapel mike for high quality video interviews ● Videography lighting consisting of Multi-20's, Multi10's, barn doors, filters and 6KW per channel dimmer ● A CANON wide angle lens ● SONY DCR VX 2100E (Digital Video Camera) for mid-range video coverage. **The Digital Camera Infrastructure:** ● Sony DSC-P92 Cyber Shot (5.0 Mega pixel) ● CANON D1X (5.3 Mega pixel) ● CANON D70 (6 Mega pixel)

Figure 3: Digital Camera Infrastructure at NAL



studying critical parameters of an aircraft. Figure 3 shows the digital camera infrastructure set up at NAL.

To aid the flight test director and the telemetry monitoring team of the SARAS aircraft, a state-of-the-art SONY digital video camera was mounted atop the telemetry tower^{7,8}. Two separate co-axial cables for video transmission and a dedicated cable for audio transmission were connected from the camera to a colour television monitor at the flight test director's table. This enabled real-time monitoring of



(a) Real-time digital videography



(b) Flight test director monitoring vital aircraft parameters



(c) SARAS aircraft in motion

Figure 4: Digital Videography: An Important Visual Aid for Studying Critical Parameters of an Aircraft, Post-Flight Analysis and Investigation

the aircraft parameters⁹. Figure 4 shows how real-time digital video aids the flight test director in monitoring aircraft parameters.

SARAS GENERATES VOLUMES OF DIGITAL VIDEO

A significant volume of SARAS digital archives was built up during the period 2002 – 2006. These are illustrated in Figure 5, listed in Table 2 and also depicted in the following chart.

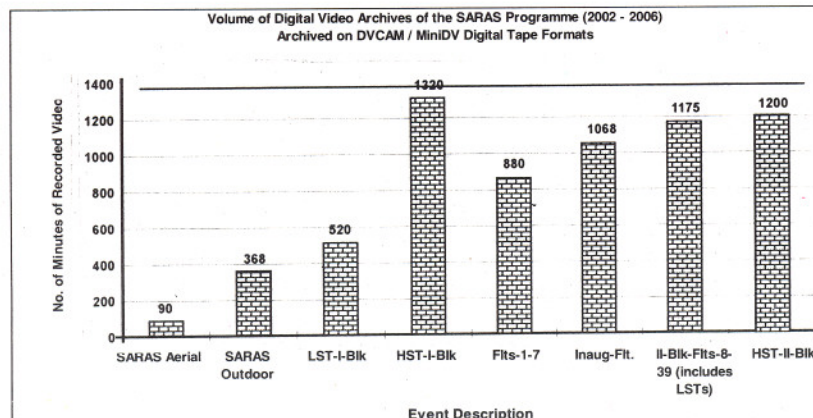
Building this digital archive was no easy task. Systematic digital initiatives which began somewhere in late

Table 2: Volume of Digital Archives built up during the period 2002 - 2006 DVCAM (Metal Evaporated) and DV (Metal Particle) Tapes

Sl. No.	Event	Media Format in which Event was Recorded	Duration (in minutes)
SARAS Aerial Footages and Outdoor Industrial Shoots			
1.	SARAS Aerial Footages	4 Mini DV Tapes	Approx. 90 minutes
2.	SARAS Outdoor Shooting (Industrial Belts) (20/11/02 to 23/11/02)	2 DVCAM Tapes	368 minutes
I – Block: SARAS Low Speed Taxi: Year 2004			
3.	SARAS Low Speed Taxi Trials (16/4/04 to 24/4/04)	13 Mini DV Tapes	520 minutes
SARAS High Speed Taxi and Flights – I Block: Year 2004			
4.	SARAS High Speed Taxi Trial – I Block (4/5/04 to 1/9/04)	45 Mini DV Tapes	1320 minutes
5.	SARAS Maiden Flight (20-5-04 to 20-8-04, includes 1-7 Flights)	22 Mini DV Tapes	880 minutes
6.	SARAS Inaugural Flight (22-8-04)	7 DVCAM and 2 Mini DV	1068 minutes
SARAS High Speed Taxi and Flights – II Block: Year 2005-2006			
7.	SARAS Flights 8 – 39 (Period: 26-1-05 to 13-2-06)	47 Mini DV Tapes	1175 minutes (@ 25 mts.per tap
8.	SARAS High Speed Taxi Trial – II Block (Period: 26-1-05 to 13-2-06)	30 Mini DV Tapes	1200 minutes



Figure 5: Chronological Digital Archives (DVCAM / MiniDV Tapes) of the SARAS Programme



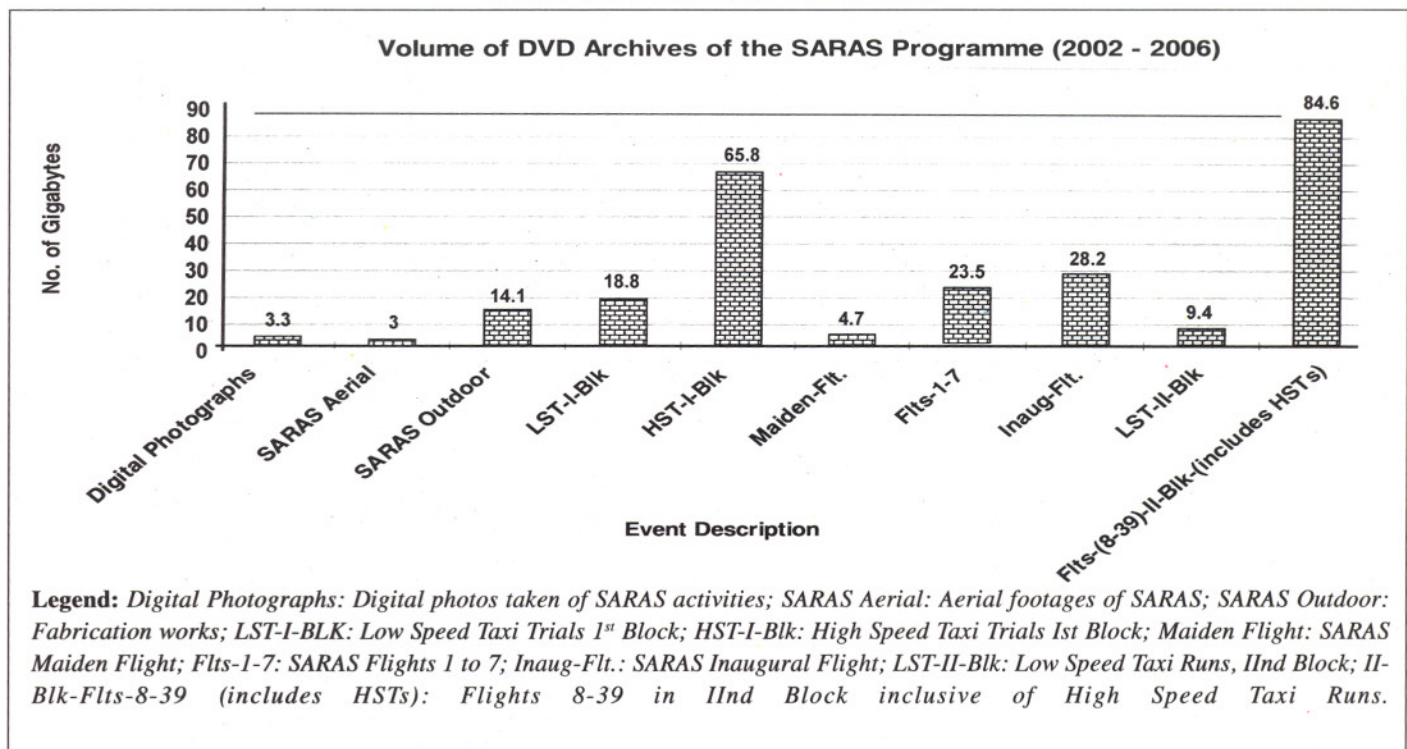
Legend: SARAS Aerial: Aerial footages of SARAS; SARAS Outdoor: Fabrication works; LST-I-BLK: Low Speed Taxi Trials 1st Block; HST-I-Blk: High Speed Taxi Trials 1st Block; Flts-1-7: Flights 1 to 7; Inaug-Flt: SARAS Inaugural Flight; II-Blk-Flts-8-39 (includes LSTs): Flights 8-39; IInd Block inclusive of Low Speed Trials; HST-II-BLK: High Speed Taxi Trials, IInd Block.

2002 are an ongoing activity till this day. Huge volumes of digital tape archives, digital photographs and DVD backups of the entire programme have been generated. All significant milestones have been chronologically labeled and archived.

Table 3 and the following chart show the growth of DVD archives in gigabytes generated in this programme.

Sl. No.	Event	Digital Archiving Media	Byte Size	Duration in Minutes
1.	Digital Photographs	1 DVD	3.3 GB	N/A
2.	SARAS Aerial Photos	1 DVD	3 GB	90 ms. (apx.)
3.	SARAS Outdoor	3 DVDs	14.1 GB	360 ms.
4.	I – Block: SARAS			
	LST: 2004	4 DVDs	18.8 GB	480 ms.
5.	I – Block: SARAS			
	HST: 2004	14 DVDs	65.8 GB	1680 ms.
6.	I – Block:			
	Maiden Flight: 2004	1 DVD	4.7 GB	120 ms.
7.	I – Block: Flights 2 – 7	5 DVDs	23.5 GB	600 ms.
8.	I – Block: SARAS			
	Inaugural Flight: 2004	6 DVDs	28.2 GB	720 ms.
9.	II – Block: SARAS			
	LST: 2005	2 DVDs	9.4 GB	240 ms.
10.	II – Block: HST:			
	2005-06	18 DVDs(till Fl.39)	84.6 GB	2160 ms.
11.	Total		255.4 GB = (0.255 Terabytes)	6000 ms.

Table 3: Volume of SARAS DVD Archives



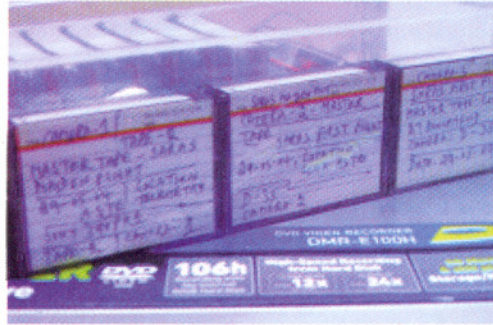




HOW WE WENT ABOUT ARCHIVING THE SARAS VIDEOS ON DIGITAL MAGNETIC TAPES

The SARAS aircraft programme has so far generated nearly 6621 minutes of digitally recorded video during the period 2002 – 2006 archived on 172 digital magnetic tapes. It was absolutely essential to come out

with a sound and robust archiving strategy to retrieve the right magnetic tape at the quickest possible time. Table 4 summarises the methodology adopted to archive the magnetic tapes.





Table 4: The methodology we adopted to archive the magnetic tapes

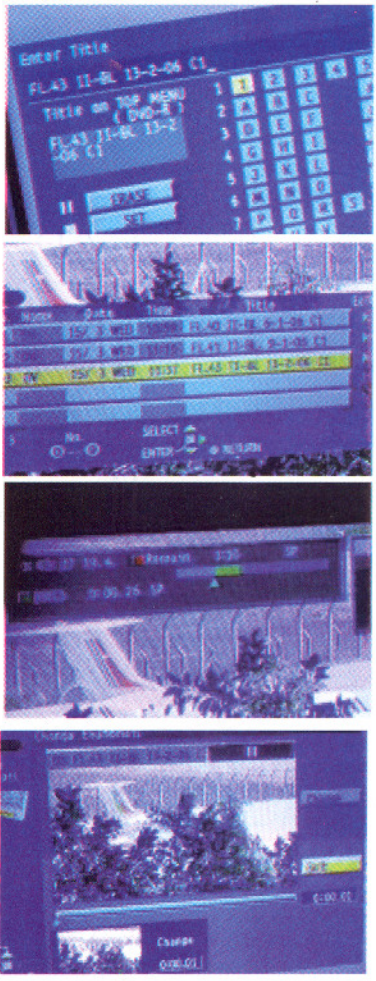
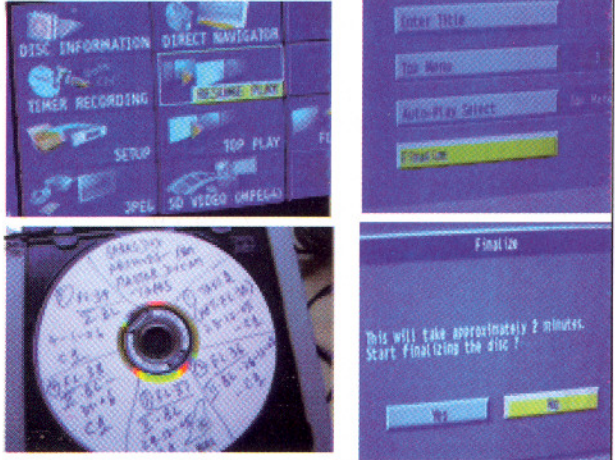
Sl.No.	Video Archiving Methodology Adopted by us.	Pictorial Representation of the Methodology
1.	<ul style="list-style-type: none"> Fields of information entered on the tape during recording are: (a) Date of the event, (b) Time of the event, (c) Event Number (Flight Number) Second level event labeling details during camera white balance as shown in figure Cameraman writes basic information on outer tape label: (event number and date) immediately after event is over. 	  <p>Basic information of date and event number is labeled by the cameraman after completion of the event. During camera white balance check before the commencement of the event, he records: (a) date, (b) time and event-name/number on the tape.</p>
2.	<ul style="list-style-type: none"> After the event, collect the tapes from cameraman and label it with more pertinent details. The field information entered are: (a) date of the event, (b) time of the event, (c) Tape No, (d) Event Name, (e) Location of the event, (f) if the same event is shot from different locations, have separate tapes with same event name but unique location names, e.g. Camera No.-1-2-3, (h) type of the Camera used. 	 <p>Same SARAS Event shot from different Locations are suitably Labeled: (Camera-1: Loc-name, Camera-2: Loc-name, Camera-3: Loc-name).</p>
3.	<ul style="list-style-type: none"> Preservation Methodology: <ul style="list-style-type: none"> (a) Arrange tapes vertically to preserve tape tension. (b) Wind tapes completely to one end to avoid tape sagging. (c) Most importantly, place 'packets' of silica gel around the tape storage area to avoid moisture collection. 	 <p>Magnetic tapes carefully preserved with 'Silica Gel' to prevent moisture collection.</p>
4.	<ul style="list-style-type: none"> Chronological archiving of tapes as the volume of digital video archives grow. Sequential organizing of the tapes with relevant Metadata descriptors to correlate the events and for easy identification of the media. Grouping of related events and appropriate labeling. <p>Metadata descriptors: (a) Box No.1, (b) SARAS HST (event name), (c) Period 4-5-2004 to 14-5-2004, (d) 1st Block.</p>	 <p>Sequential Grouping of Events for Easy Event Identification and Period Identification</p>

HOW WE CONVERTED THE DIGITAL VIDEO FROM MAGNETIC TAPES TO DVDS: THE SIGNIFICANCE OF METADATA

The SARAS programme continues to generate large amount of digital video rushes on magnetic tapes. Even though SONY's robust DVCAM technology claims an archival life span of 30 years for these tapes, it was felt necessary to look ahead to have a more secure secondary

archive mechanism. Tapes have a perennial problem of fungus collection if not stored properly. Also, the winding and re-winding operations on the tapes during video editing take a heavy toll on the tape. One cannot take risks of any sort with critical video data of an aircraft development programme of this magnitude. For storing uncompressed digital video, the DVD media was the only option. DVDs have an estimated archival life span of 100 years (subject to manufacturing quality, condition of disc before recording, quality of disc recording, handling and maintenance and environmental conditions).

Sl.No.	DVD Archiving Methodology Adopted by us.	Pictorial Representation of the Methodology
1.	<ul style="list-style-type: none"> Load the blank DVD (DVD-R, 4.7 GB) onto the digital video recorder. At the same time, power on the digital cassette recorder and player SONY DSR-45P. Ensure that both these devices handshake through the 'FireWire Cable'. Ensure appropriate video/audio connectivity for recording and also for display on the SONY monitor 	 <p><i>Loading a blank DVD onto the DVD recorder and 'FireWire' handshake between the Digital Deck and DVD Recorder</i></p> 
2.	<ul style="list-style-type: none"> Switch on the DVD recorder. Select an recording mode which is most suitable to your applications. The modes are: (a) XP (1hr.), SP (2hrs.), LP (4hrs), EP (6hrs) on a DVD-R. Typically in SP mode, you could easily fit in data of 3 MiniDV tapes or 1 (120 min.) DV CAM tape. High level of compression (for e.g. EP mode) would result in significant generation loss. 	 <p><i>Select the DVD Recording Mode with the appropriate level of Compression</i></p> 

Sl.No.	DVD Archiving Methodology Adopted by us.	Pictorial Representation of the Methodology
<p>3. ● Enter metadata descriptors at the end of each event through the Director Navigator Menu.</p> <p>● Typical fields that one needs to carefully enter here are:</p> <p>(a) Flight Event No, (b) Nature of the Event (I or II nd Blocks of testing), (c) date of the event, (d) camera location details, (e) the system on its own records:</p> <p>(i) name of the media on which recorded (DV), (ii) time and date of the recording.</p> <p>● The DVD authoring (or titling) option enables you to type the Metadata particulars: (A) most importantly one could also check the remaining time available for further recording and options to change your thumbnail display.</p>		 <p>(a) Viewing remaining recording time during recording of event, (b) Entering the titling details through the Direct Navigator, (c) Viewing the title and make changes if necessary, (d) Respective thumbnails of the related event could be modified. Titling Expansion: (a) FL.43=flight 43, (b) II-BL=II nd Block of Flights, (c) 13-2-06=Date of the Event, (D) C1=shot from Camera Location 1</p>
<p>4. ● Now comes the final stage of finalizing the DVD to make it compatible to be played from any Desktop PC or any conventional DVD player.</p> <p>● From the Functions Menu on the Remote, select the Disc Information and choose Finalize. The entire finalizing operation takes 2 minutes.</p> <p>● Once the DVD if finalized, it cannot be further edited or modified. Only by finalizing portability is possible.</p> <p>● Relevant video data is already digitized in standard MPEG-2 format. Infact, it is possible digitize video in MPEG-4 and also JPEG images.</p> <p>● Once this is done, it is equally important to label the DVDs with relevant Metadata information about the contents of the DVD for quick information retrieval.</p>		 <p>(a), (b), (c): Finalizing the DVD using the Functions Menu for permanent content recording, (d) Labeling of the DVD: (a) FL.36=Flight 36, (b) II.BL=II nd Block of Flights, (c) 26-12-05=Date of the event, (d) C1=Camera Location 1.</p>

DIGITAL VIDEO ARCHIVES: MANAGING CONTENT THROUGH METADATA

Video that is "born digital"¹⁰ will have increasing amounts of descriptive information automatically created during the production process, e.g. digital cameras that record the time and place of each captured shot, and tagging video streams with terms and conditions of use. Such metadata could be augmented with higher-order descriptors, e.g. details about actions, topics, or events. These descriptors could be produced automatically through ex-post-facto analysis of the aural and visual contents in the video data stream. As digital video archives grow, both through the increasing volume of new digital video productions and the conversion of the analog audio-visual record, the need for metadata similarly increases. Automatic analysis of video in support of content-based retrieval will become a necessary step in managing the video archives. Wactlar and Christel¹⁰ lay particular emphasis on the Informedia Project at the Carnegie Mellon University and the new National Institute of Standards and Technology Text Retrieval Conference (NIST TREC) Video Retrieval Track, which are investigating content-based retrieval from digital video. They are of the opinion that without metadata, a thousand-hour digital video archive is reduced to a terabyte or greater jumble of bits; with metadata, those thousand hours can become a valuable information resource.

Wactlar and Christel argue that for long-term preservation, digital video presents a number of challenges. Many questions arise. What should be the sampling and quantization rates be? What compression strategies should be used – lossy or lossless? What media should be used to store the resulting digital files – optical (such as digital video disc [DVD]) or magnetic? What is the shelf life for such media, i.e., how often should the digital records be transferred to new media? What are the environmental factors for long-term media storage? What decompression software is needed for subsequent extraction of video recordings? Regardless of how these challenges are addressed, digital video has huge size, but also huge potential, for facilitating access to video archive material. Digital technology has the potential to improve access to research material, allowing access to precisely the content sought by an end user. To realize this potential, video must be described so that its production attributes are preserved and so users can navigate to the content meeting their needs. Video has a temporal aspect, in which its contents are revealed over time, i.e., it is isochronal. Finding a nugget of information within an hour of video could take a user an hour of viewing time. Video production is becoming a digital process, with new equipment such as digital cameras supporting the capture of metadata such as date, time, and

location at the recording time. The Society of Motion Picture and Television Engineers (SMPTE) has been working on a universal preservation format for videos, the SMPTE Meta Dictionary (SMPTE 2000). For "born digital" material, many of the metadata elements can be filled in during the media creation process.

The new member of the MPEG family¹¹, Multimedia Content Description Interface or MPEG-7, aims at providing standardized core technologies allowing description of audiovisual data content in multimedia environments. Considering the popularity of XML, MPEG will have XML Schema as the language choice for the textual representation of content description. Usage of XML will facilitate inter-operability in the future. MPEG-21 could be described as the integration of the critical technologies enabling transparent and augmented use of multimedia resources across a wide range of networks and devices to support functions such as content creation, content production, content distribution, content consumption, content packaging, IP management and protection, content identification and description, user privacy, content representation and event reporting.

Figure 6 shows how metadata information has been useful in storing and quick retrieval of digital information with regard to the digital archives that the SARAS aircraft programme has generated. At NAL, a systematic methodology was followed for etching vital information on the digital video tape itself (a facility provided by high-end digital video cameras) regarding the number of the flight event, the date of the flight or flight test event, the time of the event, using the camera menu options before the commencement of each important event. Simultaneously after the event was completed, the digital tapes were labeled with all relevant flight details and stored chronologically. Related set of events were then simultaneously recorded on a digital video recorder indicating all flight details in the titling menu provided by the recorder so that even a lay man could pick out the right tape or a DVD if some information is sought. However, finding that nugget of information within an hour of video through searchable databases requires further investment to set up necessary infrastructure.

CONCLUSION

Archivists and preservationists are vested with selecting a medium that will survive the longest and a system that will transcend the most generations of "player" hardware and software. Media longevity problems exist both for analog and for digital content¹⁰.

"MetaData provide the window of access into a Digital Archive"
"Quality of a Digital Video Archive is Sine-qua-non with its MetaData"

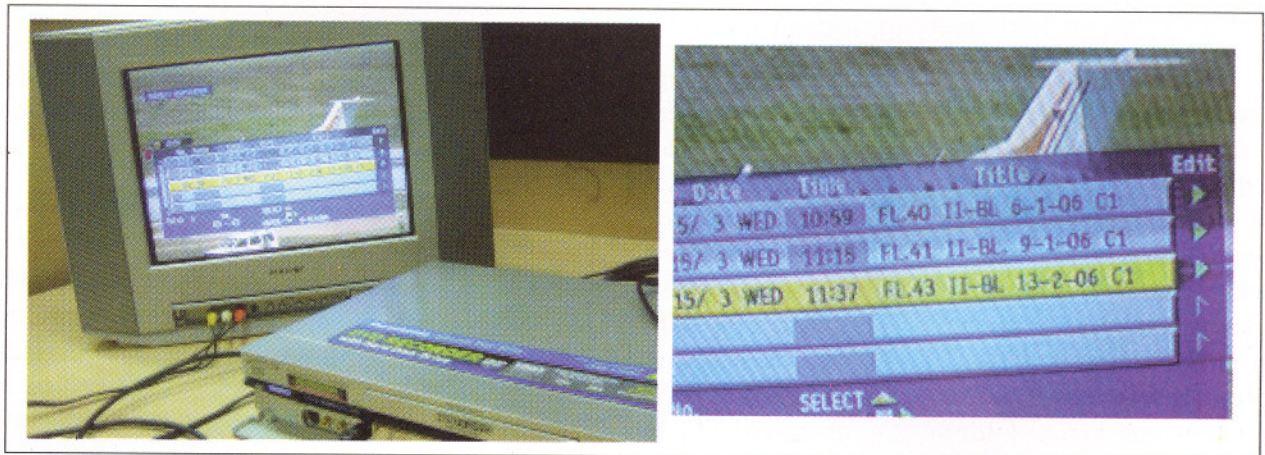


Figure – 6 (a): Direct Navigator Interface in the Digital Video Recorder Helps to store, modify and erase MetaData Description

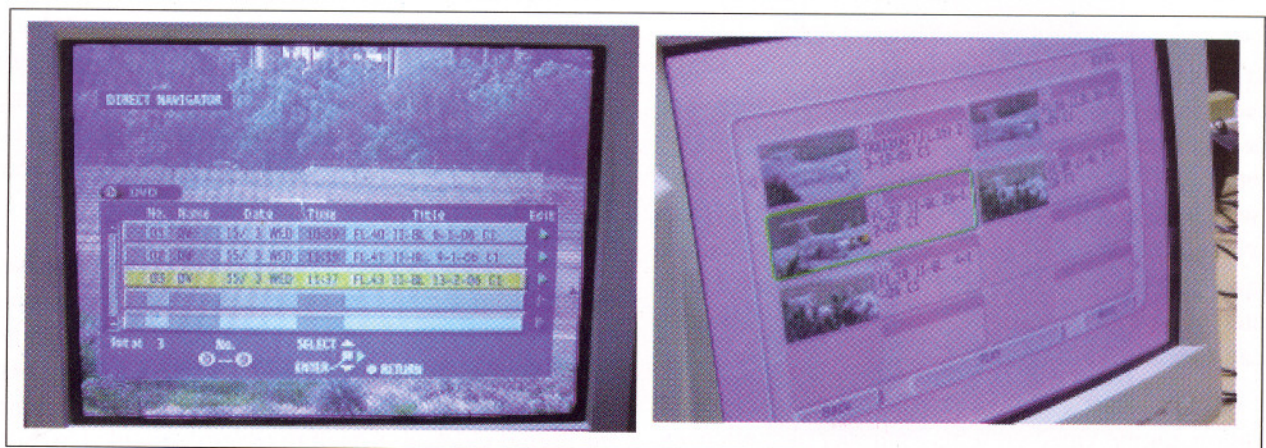


Figure – 6 (b): A Finalized DVD is compatible to be played, viewed, searched and navigable on any Conventional PC Desktop with all relevant MetaData Description

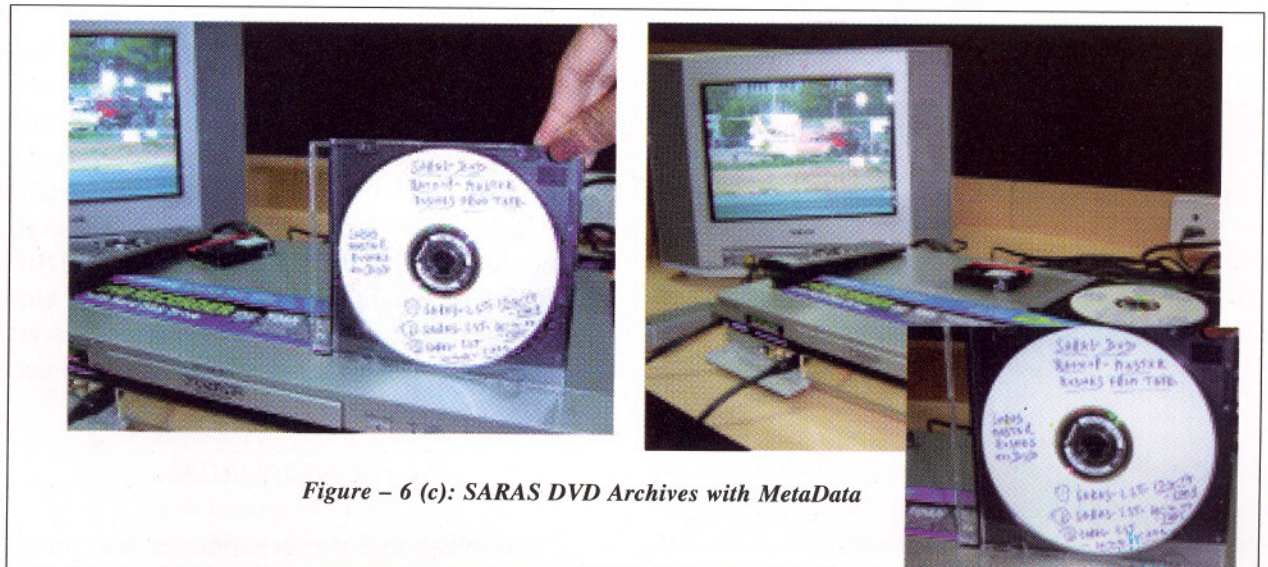



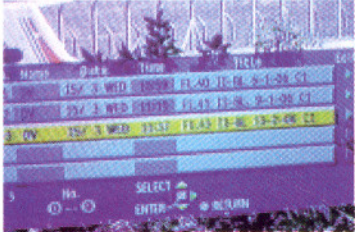
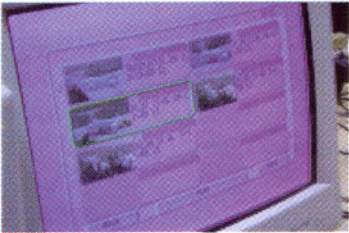
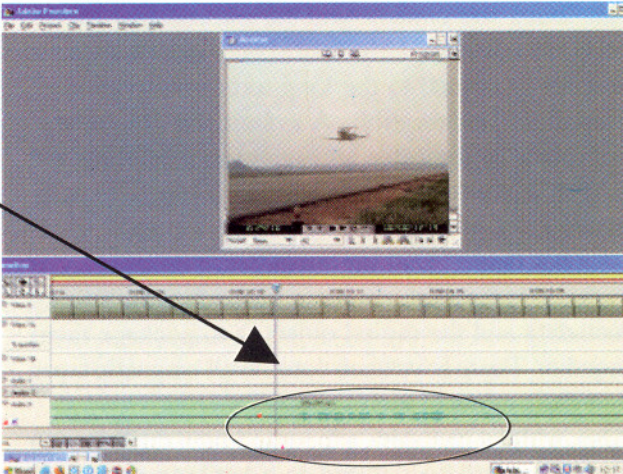


Figure – 6 (c): SARAS DVD Archives with MetaData

FOOTAGE RETRIEVAL

Table 7: Briefly highlights as to how at present we go about retrieving the right information.

SI.No. A Sample Query to retrieve a Specific Digital Video Footage	Best Ways of Retrieving Digital Video Information With Existing Infrastructure
<p>1. ● Give me that part of the video clip where the Pilot Talks to the Test Director saying “SARAS lift off at 108” during the first experimental flight: How do we go about from our tape archives.</p> <p>(a) Locate that particular tape of the event from the chronologically arranged archives.</p> <p>(b) Ascertain the exact time code location of the event by playing the tape on the digital deck.</p> <p>(c) Digitize only that portion of the video onto the video editing system</p> <p>(d) Output the video onto a suitable MPEG format along with the encoded audio and pass it onto the technical team.</p> <p>(e) If such a facility is not available, choose the digitized DVD containing that particular event either through the Direct Navigator Menu on the DVD recorder or navigate to that particular event from a conventional desktop PC.</p> <p>(f) Bring in the entire digitized video of that particular event into the timeline of Adobe Premiere.</p> <p>(g) If approximate time of the event is known, go directly to that place using the timeline using Premiere, or else look for those ‘significant spikes’ in the audio wave patterns which come onto the timeline from the digitized video.</p> <p>(h) If the track has more occurrences of audio,ascertain the approx. time of the event, reach the desired spot using the timeline and the Monitor Preview on Premiere.</p>	<div></div> <div></div> <div></div> <div></div> <div></div> <div></div> <p><i>Conversation of Pilot to Test Director regarding “SARAS Lift Off at 108” located at 12:19 on the Timeline</i></p>

If (g) proves difficult, use the combination of slow search, frame by frame search, the time slip function or the Play/x1.3 function. Else use the play list option from the Director Navigator to go to your desired location. Added to this, powerful features of Timer and Memory recordings and recall are built into the DVD recorder.

As the SARAS activity picked up momentum, the NAL management felt the great need to have a robust hardware and software platform to capture (videograph), digitize and archive SARAS digital content. A timely proposal around May 1992 to set up a state-of-the-art multimedia lab for non-linear video editing and 3-D animations paved the way for some very significant spin-offs. Another technical proposal closely followed in having our own in-house professional digital videography equipment for field productions which made it possible to archive the SARAS programme. Some of the most significant spin-offs these exercises have generated are listed below:-

- The SARAS programme has generated so far close to 6621 minutes of digitally recorded video during the period 2002-2006 archived on to 172 digital magnetictapes.
- Close to 0.255 terabytes of SARAS digital video have been archived onto over 55 DVDs.
- Real-time digital videography is extremely crucial to a flight test director. During critical phases like take off and landing of an aircraft, availability of real-time video gives a better appreciation of the aircraft attitude, pitch angle and flare to the test director. NAL's in-house investment on digital video camera infrastructure significantly aided this operation.
- Digital video is an important visual aid for all post-flight analysis, investigations and monitoring aircraft performance to the technical teams.
- These archives also served as immediate raw material for many SARAS related presentations, brochures and posters (for exhibitions). Most importantly these video archives helped significantly in bringing out several in-house multimedia films on SARAS.
- There is no doubt that the lifetime of the metadata that index the content will far exceed that of the original content. This contextual information is absolutely crucial to the long-term preservation of electronic information. A systematic 'metadata' approach in digitally archiving and labeling the SARAS events has made it possible for ready availability of high quality digital footages to all SARAS teams. Linking metadata with content is another important strategy. One way of linking metadata and the digital object is to package them together. These have been done on all magnetic tapes and their relevant archived DVDs.
- Also, without metadata, a thousand-hour digital video archive would be reduced to a terabyte or greater

jumble of bits; with metadata, those thousand hours can become a valuable information resource.

● This timely investment that NAL had made towards setting up of an in-house state-of-the-art multimedia laboratory and the right digital video camera infrastructure, made it possible to bring out several in-house VCD and DVD films on the SARAS programme and other NAL R&D activities meeting the professional broadcast standards.

The work presented in this paper attempts to describe how important are digital videos and digital archiving in a civil aircraft development programme like SARAS. The importance of 'metadata' in preserving all these thousand hours of digital content for the 'posterity' is also highlighted in this paper.

The road ahead is definitely very exciting and interesting as finding that 'nugget' of information within an hour of video through innovative and interactive user interfaces and 'query able' databases of metadata requires further investment to set up the necessary infrastructure.

In this context, it would very apt to refer to the famous aphorism from Robert Frost's poem "Mending Wall" that "*good fences make good neighbours*". Likewise, "*good archives make good scholars*"¹². Digital works force a new paradigm of preserving disembodied content, and making sure that content will be viewable far into the future. By combining their vast set of skills in handling analog objects as well as moving to new paradigms provoked by the digital age, moving image archivists can continue to play a crucial role in preserving our cultural heritage and ensuring that today's works will last well beyond the life of the team that produces them¹¹.

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